

ART. XXIII.—*The Anatomy of the Slug, Cystopelta petterdi, var. purpurea, var. nov.*

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(With Plates LXIV-LXIX.).

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Since the description given by Mr. Hedley in 1890 no further work has been done, so far as I can discover, on *Cystopelta petterdi*. Professor Spencer and Mr. Hedley therefore suggested that I should give a fuller account of the anatomy of this animal.

In the Biological Department of the Melbourne University were some preserved specimens, some of which came from Beech Forest, Victoria, and were preserved in spirit, and so contracted as to be of no use for external description or dissection. These were used in sections, being stained with acetic acid alum carmine. The rest came from Fernshawe, Victoria, and were preserved in formalin. Later I found two living specimens at Narbethong, Victoria. These I used for dissection and external description.

Professor Tate gave a short description of *Cystopelta petterdi* in the Report of the Royal Society of Tasmania, 1880. A description and drawing of the animal has also been given by Mr. C. Hedley in the Proceedings of the Linnean Society of New South Wales, 1890.

External Features and General Description. (Fig I.)

The animal is small and slug-like, with its organs drawn into a dorsal hump as in snails, but no spiral twisting is visible from the exterior. The hump is very large, extending from just behind the reproductive opening anteriorly, to overhang about half the free portion of the foot posteriorly. In colouring, my specimens resemble neither those described by Mr. Hedley nor

those described by Professor Tate. The two living specimens were pale grey, with two short darker lines on either side of the posterior end of the foot, and on the dorsal surface of the shield a few bright violet spots. At the posterior end the foot is divided into three lobes, where the mucous pore is situated, and from this a pedal groove runs along either side of the foot to the anterior end. The whole of the under-surface of these grooves is ciliated, the cilia extending right round the surface of the foot. (Figs. 5 to 12.) The pulmonary opening cuts well into the edge of the shield; the reproductive opening is situated just below the right superior tentacle, and slightly posterior to it. There is no trace of a shell. The alimentary canal, liver, kidney, heart, and some of the reproductive organs are all drawn up, forming a visceral hump beneath the shield; none of the organs extending to the posterior end of the foot, as in the *Limacidae*. I took the following measurements from a living specimen:—Length of foot, 19.5 mm.; length of shield, 16.7 mm.; depth of shield, 3.75 mm. The dorsal wall of the hump is thick; the anterior portion, being very vascular, forms the respiratory organ, while the sides of the under wall at its posterior end are very thin, the organs being slightly visible through it.

Organs of the Mantle Cavity.

The *heart* occupies the left ventral corner of the mantle cavity, being covered dorsally and on the right side by the kidney. The ventricle (Figs. 4, 7, 8) is oval in shape, and has numerous muscles running in every direction through its walls. The auricle (Fig. 6) is much smaller than the ventricle, and very slightly muscular. The pericardium (Figs. 4, 6, 7, 8) lies close to the heart, except on the left side, where it is nearer the body wall, and on the right side at the region of the reno-pericardial opening (Fig. 4). It is a delicate, but very definite membrane, the nuclei in its cells showing up very plainly in sections. I was unable to determine the course of the blood vessels, excepting the main ones, which do not seem to differ at all from those of other forms. One vessel (Fig. 4) runs up from the ventricle through the reno-pericardial canal.

The *kidney* (Figs. 4, 6, 7, 8, 13) is a large mass forming a spongework occupying the greater part of the mantle cavity. It consists of masses of cells and tubules, the tubules being in greater number and more conspicuous on the dorsal surface. (Fig. 13). These finally open into the ureter, which runs along the dorsal surface of the kidney to the right side, where it descends and opens to the exterior (Figs. 7, 13) just in front of the anus. Among the cells we can distinguish three kinds—(1) small granular cells, (2) larger clear cells with distinct nuclei, (3) cells which are stained brown and which may not be a distinct kind from the small granular cells, the difference in staining being perhaps due to the presence of inorganic material.

The *Renopericardial canal* (Fig. 4) is more difficult to make out than in other forms, probably owing to the irregular shape of the kidney and to the presence of a blood vessel in it. In all the three series of transverse sections I examined, it appears to be double at its cardiac end, but the lower branch ends blindly, the upper alone really forming a renopericardial canal. The figure of the section given recalls the figure in J. T. Cunningham's paper on "The Renal Organs of *Patella*."¹ The similarity suggests to me that the lower may be a vestigial second renopericardial canal.

The Reproductive System.

In the description given by Mr. Hedley he says: "The genital system appears much contorted at its orifice, after which it divides into three portions—the duct of the genital bladder, which is rather short, twisted, and continuing after reaching the genital bladder, is again expanded into a second sac; the penis, stout and pyriform, invaginated upon itself and produced into a slender flagellum; and the vagina, long and slender, and also invaginated upon itself." The following is a description of the reproductive system as made out from specimens I have examined, which differ, as will be seen, in a few points from those examined by Mr. Hedley.

¹ Q.J.M.S., vol. xxiii.

The *Hermaphrodite gland* (Figs. 2, 10, 11, 12) is comparatively large. It is situated on the right side of the visceral mass posterior to the mantle cavity, being surrounded on its left and partly on its ventral sides by the liver. It is a compact gland made up of a number of lobules; the male elements are arranged in groups towards the centre of each lobule, and the female elements are arranged round these.

The *Hermaphrodite duct* (Figs. 2, 11, 12) leaves the hermaphrodite gland from about its centre and runs in a sinuous course to the albumen gland, entering the latter along the right side towards the posterior end. It is a simple, thin-walled tube.

The *Albumen gland* (Figs. 2, 9, 10, and 11) is not so compact as the hermaphrodite gland. It consists of tubules and lobules. Towards its anterior end it really surrounds the common duct, so that it is only in section that the boundary of duct and gland can be seen, and then with difficulty, owing to the large number of tubules in the gland.

The *Common duct* (Figs. 2, 9, 10) is very short, and divides almost before leaving the albumen gland into oviduct and vas deferens.

The *Vas deferens* (Figs. 2, 7, 8, 9, 15) is a long narrow duct, ciliated towards its anterior end. It leaves the common duct on the left side and runs up, behind, round, and across the amatorial organ, across the oviduct, and widens to end in the penis.

The *Penis* (Figs. 2, 7, 8) is a large protrusible muscular organ, with the retractor muscle attached towards its posterior end; just behind this is a large globular swollen portion. The penis leads into a common genital atrium.

The *Oviduct* (Figs. 2, 6, 7, 8, 15) is a long tube leaving the common duct on its right side, and running fairly straight to the anterior end, where its walls become swollen and invaginated just before its opening into its common genital atrium.

The *Amatorial organ* (Figs. 2, 6, 7, 8, 14). What Mr. Hedley describes as "the duct of the genital bladder . . . expanded into a second sac," I take to be the amatorial organ. It is a large swollen body, running right back to the level of the albumen gland, to end blindly at that region. It has very thick walls beset with numerous glands, which all open into a central

lumen. The organ opens anteriorly into the common genital atrium.

The *Common genital atrium* (Figs. 2, 5, 6, 7, 8) receives the openings of the penis, the oviduct, and the amatorial organ. It opens to the exterior by the reproductive opening situated just slightly posterior and ventral to the right superior tentacle (Fig. 1). The penis can be protruded through the atrium, and the reproductive opening to the exterior.

The Alimentary System.

The *Mouth* is situated on the ventral surface, and leads into the buccal cavity. The buccal mass occupies most of the anterior part of the head (Fig. 5). The buccal bulb is lined by an epithelium of columnar cells, with very distinct nuclei, the walls are very muscular, the two lateral ones extremely so. The jaw has been described by Mr. Hedley. In section it is seen to consist of a layer of chitin, which stains deeply, with a serrated free edge; the serrations all pointing in the same direction. (Fig. 5.) Under this chitinous layer is a layer of oblong cells with large granular nuclei, the nuclei all being arranged at the ends of the cells away from the chitinous layer.

The *Radula* (Fig. 6) is so deeply stained in my sections that nothing can be made out of the teeth, but under them is a very clear epithelium, composed of cells with large granular nuclei, and under this a pad of muscle fibres and connective tissue. The radula consists of about ninety-six rows of very fine teeth. The shapes of these teeth were distinguished from preparations of the radula both unstained and stained with picro-carmin.

The *Rachidian* (Fig. 3) is tricuspid, the three cusps twisting around each other in such a manner that it is only by careful focussing that the shape can be seen. The base is roughly conoid.

The shapes of the laterals and marginals which gradually merge into one another can be best understood by reference to the figure (Fig. 3), which represents some of them from a lateral view, taken from a teased radula and arranged as far as possible in order.

The *Oesophagus* (Figs. 5. to 10) commences as a fairly straight wide ciliated tube compressed dorso-vertically. This portion of it receives the ducts from the salivary glands; it then becomes narrower (Figs. 7, 8, 9) and continues as a narrow tube till it reaches almost the middle of the visceral mass, where it widens to enter the stomach (Fig. 10). It is lined by a mucous epithelium of large, clear cells, with granular nuclei, the nuclei being situated at the ends of the cells away from the lumen of the tube. This epithelium, which is thrown into folds, forms the greater part of the walls of the tube (Fig. 17).

The *Stomach* (Figs. 9, 10, 11, 12, 17) is a very large dilated sac on the left side of the posterior end of the visceral mass. It is almost completely surrounded by the liver. Its walls, towards its anterior end, consist of a thin muscular layer, lined by a simple epithelium, the cells of which are not well defined, and the nuclei are indistinct. The oesophagus enters the stomach ventrally at its anterior end (Fig. 10), and here the lining epithelium is slightly thrown into folds, and the cells with their nuclei are more definite. At the posterior end (Figs. 11 and 12) the walls become thickened and nuclei of the lining membrane more definite, the membrane itself forming folds. This posterior part is probably the true stomach, the anterior part representing a crop. Under a high power (Fig. 17) the membrane is seen to consist of long narrow cells with large granular nuclei. Also there are other cells which are vacuolated. Outside the membrane is a muscular layer. The stomach receives the hepatic ducts.

The stomach opens into the *Intestine* which runs up between the liver and the hermaphrodite gland (Figs. 9, 10, 11, 12, 17) along the dorsal surface of the visceral hump, dorsal to the hermaphrodite gland, and opens into the rectum (Figs. 9 and 10), which runs forward between the hermaphrodite gland and the body-wall to open to the exterior, just behind the opening of the ureter, by the pulmonary opening. The lining membrane of the intestine (Fig. 17) is very like that of the stomach, but there are no vacuoles nor a definite muscle larger in the intestine. The intestine is smaller in diameter than the stomach, but it dilates to form the rectum.

The *Salivary glands* (Figs. 8, 9, 10) lie on either side of the oesophagus, at the anterior end dorsal to it, but further back

they surround it. In them can be distinguished two kinds of cells, very fine granular cells, with large granular nuclei and distinct nucleoli, some of which cells are vacuolated, and smaller cells, which stain more deeply. From each gland a duct runs up to open into the oesophagus (Fig. 5) just before it leaves the buccal mass.

The *Liver* (Figs. 8 to 12) is a large organ situated about the middle of the visceral mass, and more or less surrounding the hermaphrodite and albumen glands, the stomach and the intestine. It consists of a large number of caeca bound together by connective tissue. The lumina of the caeca are bounded by cells, which are probably secretory, and contain masses of small brown-stained particles.

The Nervous System.

There do not seem to be any notable differences in the structure of the nervous system of this species from that of other forms.

The *Cerebral ganglia* (Figs. 7 and 8) are two large pyriform masses lying on either side of the oesophagus, at their posterior ends swelling out dorsally to lie right across it, so as to form, with the pedal and visceropleural ganglia, a collar round the oesophagus (Fig. 7). The cerebral commissure (Fig. 7) is short, connecting the two ganglia across the oesophagus. Anteriorly two short buccal nerves run forwards, and just beside the salivary ducts, from the two buccal ganglia (Fig. 6), which are connected by the buccal commissure. Nerves from the buccal ganglia supply the buccal mass. The tentacular nerves are very large, and arise from the outer sides of the cerebral ganglia towards their anterior ends. (Fig. 7.) Labial nerves also arise from the cerebral ganglia, and far forward give rise to labial ganglia.

The *Pedal and Visceropleural ganglia* (Figs. 7 and 8) lie very close together, forming the sub-oesophageal ganglionic mass. The visceropleural ganglia are situated slightly dorso-lateral to the pedal ganglia. The ganglia are connected by commissures, and also there are the cerebro-pedal, cerebro-visceral, etc., connectives, as in other forms. From the pedal

ganglia a number of nerves pass to the foot, and from the visceropleural ganglia nerves pass to the body wall and to the different viscera. The ganglia consist of nerve fibres in the centre, and surrounding these the typical ganglionic cells, large and granular, with branching processes and very distinct nuclei, and smaller granular nucleated cells. The whole ganglion is bounded by an outer fibrous membrane.

Sense Organs.

These are the eyes, otocysts and sense papillae.

The *Eyes* do not differ from those of other forms.

The *Otocysts* (Figs. 8 and 16) are two semi-lunar sacs situated on the outer dorsal sides of the pedal ganglia. The walls of these sacs appear to be formed by a thickening of the outer membrane of the ganglia. In the walls are rounded granular cells. The cavities contain minute particles, which I take to be the calcareous otoliths, although I could not prove them to be calcareous, probably owing to the acid I had used in staining my specimens. In the inner corner of each otocyst is a minute patch of cilia. The auditory nerves run down beside the pleural ganglia to enter the posterior ends of the otocysts, having their origin in the cerebral ganglia.

Pedal Gland.

Pedal gland (Figs. 5 to 12). This is a large gland extending down almost the entire length of the foot, becoming larger at its anterior and posterior ends, the median portion being compressed by the visceral mass. It has a ciliated opening anteriorly (Fig. 5) in the mid-line between the snout and anterior part of the foot, and a posterior opening by the caudal mucous pore. It consists of large, slightly granular gland-cells, with large rounded granular nuclei and distinct nucleoli, connective tissue and small granular cells. A great deal of mucus is present, and takes the stain very readily. The median walls of the gland surround a space which is ciliated, more particularly the anterior portion. This acts as a duct for the gland. Besides this large pedal gland the whole surface of the animal

is covered with unicellular glands, many of which contain the deeply-stained mucus.

Cystopelta at one time was placed in the *Limacidae*. Later Tryon put in the *Tebennophoridae*, while Mr. Hedley's classification is:—Family, Zonitidae; Sub-family, Helicarionnae; Genus, *Cystopelta*.

The few differences I have noted in the specimens described by Professor Tate, Mr. Hedley and myself incline me to the belief suggested by Mr. Hedley in his paper, that the Tasmanian, Victorian and New South Wales forms may in reality be different species, but until they can be fully worked I prefer to look on the Victorian form as a new variety which I name "*purpurea*."

I now wish to thank Professor Spencer, under whom this work has been carried out, for his advice and assistance; also Mr. Hedley, Dr. Hall and others who at times have helped me out of difficulties.

LITERATURE.

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Hedley, C.—"On the Structure and Systematic Position of *Cystopelta*." Proc. Linn. Soc., N.S. Wales, vol. v., 1890.

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EXPLANATION OF PLATES.

In all figures:—

- A.G. Albumen gland.
- A.O. Amatory organ.
- A.O.O. Opening of the amatory organ into the genital atrium.
- AUR. Auricle.
- B.C. Buccal cavity.
- B.G. Buccal ganglia.
- B.M. Buccal mass.
- B.V. Blood vessel.
- C. Cilia.

C.D.	Common duct.
C.G.	Cerebral ganglia.
C.G.A.	Common genital atrium.
E.	Eye.
F.	Foot.
Gl.	Glands.
H.D.	Hermaphrodite duct.
H.G.	Hermaphrodite gland.
I.	Intestine.
J.	Jaw.
K.	Kidney.
L.	Liver.
L.D.	Liver duct.
L.T.	Lateral tooth.
LU.	Lumen.
M.	Mouth.
M.C.	Mantle cavity.
MG.	Marginal tooth.
MUS.	Muscle.
N.	Nerve.
O.	Oesophagus.
OD.	Oviduct.
OL.	Otoliths.
OT.	Otocyst.
P.	Penis.
P.C.	Pericardium.
P.G.	Pedal ganglia.
P.Gl.	Pedal gland.
P.Gl.D.	Duct of pedal gland.
P.Gl.O.	Opening of pedal gland.
P.Gr.	Pedal groove
P.O.	Pulmonary opening.
R.	Rectum.
RAC.	Rachidian.
RAD.	Radula.
R.M.	Retractor muscle.
R.O.	Reproductive opening.
R.P.C.	Renopericardial canal.
S.	Stomach.

S.D.	Salivary duct.
S.D.O.	Opening of salivary duct into oesophagus.
S.G.	Salivary gland.
SP.	Spermatozoa.
T.I.	Inferior tentacle.
T.S.	Superior tentacle.
U.	Ureter.
U.M.G.	Unicellular mucous gland.
U.O.	Opening of ureter.
V.	Ventricle.
VAC.	Vacuole.
V.D.	Vas deferens.
V.H.	Visceral hump.
V.P.G.	Visceropleural ganglia.

Fig. 1. Whole animal.

Fig. 2. Reproductive system.

Fig. 3. Teeth.

Fig. 4. Reno-pericardial canal.

Figs. 5 to 12 (inclusive) are typical transverse sections taken in order, Fig. 5 being most anterior.

Fig. 5. Section through buccal mass. Shows opening of salivary ducts into oesophagus, and the anterior opening of the pedal gland and posterior part of reproductive opening.

Fig. 6 shows the opening of the amatory organ into the common genital atrium, and the invagination of the oviduct.

Fig. 7. Section at level of the pulmonary opening, shows the relative positions of the chief nerve ganglia. The tentacular nerve crossing to the tentacle.

Fig. 8 shows the otocysts *in situ* on the pedal ganglia.

Fig. 9 shows the oesophagus surrounded by the salivary glands; the complicated nature of the common duct; the rectum just posterior to its opening to the exterior; and the albumen gland free from the common duct.

Fig. 10. The manner in which the common duct becomes, as it were, part of the albumen gland; position of the salivary glands; opening of oesophagus into stomach.

Fig. 11. Section just after the foot becomes free. Shows hermaphrodite gland with spermatozoa very distinct; her-

maphrodite duct entering the albumen gland; and portion of stomach where its mucous lining is thrown into folds.

Fig. 12. Hermaphrodite duct leaving hermaphrodite gland.

Fig. 13. Ureter at point of opening into the mantle cavity.

Fig. 14. Amatory organ, showing its glandular walls.

Fig. 15. Vas deferens (ciliated) and oviduct.

Fig. 16. Otocyst.

Fig. 17. High power drawing of stomach, intestine, rectum and oesophagus.
